

CLAIMS

What is claimed is:

1. An energy saving circuit that communicates with a receiver of a first physical layer of a first network device, comprising:

a sense circuit that communicates with said receiver and that generates a receive signal when connection activity that exceeds a first threshold is detected by said receiver,

wherein said energy saving circuit powers down said first physical layer when said receiver does not detect said connection activity for a first predetermined period to reduce power consumption of said first physical layer.

2. The energy saving circuit of claim 1 further comprising:

an autonegotiation circuit that communicates with said sense circuit and that powers up said first physical layer and attempts to negotiate a connection with a second physical layer of a second network device when said sense circuit generates said receive signal.

3. The energy saving circuit of claim 2 wherein said sense circuit enters a sense state and powers down said first physical layer when said sense circuit is reset.

4. The energy saving circuit of claim 3 further comprising a first timer that generates a first signal after a first period.

5. The energy saving circuit of claim 4 wherein said first timer is reset whenever said receive signal is generated by said sense circuit.

6. The energy saving circuit of claim 5 wherein if said first timer times out before autonegotiation is complete, said sense circuit powers down said first physical layer and returns to said sense state.

7. The energy saving circuit of claim 2 further comprising a link circuit that triggers a link state when autonegotiation is complete and a link with said second physical layer is established.

8. The energy saving circuit of claim 7 wherein said link circuit generates a link lost signal when said link is lost.

9. The energy saving circuit of claim 3 wherein said sense circuit includes a second timer that communicates with a transmitter.

10. The energy saving circuit of claim 9 wherein when said second timer times out, said transmitter is turned on and generates a pulse.

11. The energy saving circuit of claim 10 wherein after said transmitter generates said pulse, said transmitter is turned off and said sense circuit returns to said sense state.

12. The energy saving circuit of claim 11 wherein said second timer has a second period that is longer than a period of fast link pulse bursts.

13. The energy saving circuit of claim 1 further comprising a switching circuit that senses a connection configuration of said second physical layer and that adjusts a connection configuration of said first physical layer to match said connection configuration of said second physical layer.

14. The energy saving circuit of claim 1 further comprising a status indicator that generates a status signal to notify said first network device of a power status of said first physical layer.

15. A first network device including a first physical layer that establishes and maintains a connection to a second physical layer of a second network device, said first physical layer comprising:

a receiver that detects connection activity; and

an energy saving circuit that communicates with said receiver and that has a first energy saving mode that powers down said first physical layer when said receiver does not detect said connection activity for a first predetermined period.

16. The first network device of claim 15 further comprising a transmitter that communicates with said energy saving circuit.

17. The first network device of claim 16 wherein said energy saving circuit has a second energy saving mode that periodically powers up said transmitter, generates a link pulse using said transmitter and then powers down said transmitter.

18. The first network device of claim 17 wherein said energy saving circuit includes a sense circuit that communicates with said receiver and that generates a receive signal when said connection activity is detected by said receiver.

19. The first network device of claim 18 wherein said energy saving circuit includes an autonegotiation circuit that communicates with said sense circuit and that attempts to negotiate a connection with said second physical layer when said sense circuit generates said receive signal.

20. The first network device of claim 19 wherein said sense circuit enters a sense state and powers down said first physical layer when said sense circuit is reset.

21. The first network device of claim 20 further comprising a first timer that generates a first signal after a first period.

22. The first network device of claim 21 wherein said first timer is reset whenever said receive signal is generated by said sense circuit.

23. The first network device of claim 22 further comprising a link circuit that communicates with said autonegotiation circuit and that enters a link state when autonegotiation is successful and a link with said second physical layer is established.

24. The first network device of claim 23 wherein said link circuit generates a link lost signal when said link is lost.

25. The first network device of claim 22 wherein if said first timer times out before autonegotiation has completed, said sense circuit powers down said first physical layer and returns to said sense state.

26. The first network device of claim 18 wherein said sense circuit includes a second timer that communicates with a transmitter.

27. The first network device of claim 26 wherein when said second timer times out, said second timer generates said link pulse.

28. The first network device of claim 27 wherein said second timer has a second period that is longer than a period of fast link pulse bursts.

29. The first network device of claim 27 wherein after said transmitter generates said link pulse, said transmitter is turned off and said sense circuit returns to said sense state.

MP0083-APP-000006

30. An energy saving circuit that communicates with a receiver of a first physical layer of a first network device, comprising:

a sensing means for communicating with said receiver and for generating a receive signal when connection activity that exceeds a first threshold is detected by said receiver,

wherein said energy saving circuit powers down said first physical layer when said receiver does not detect said connection activity for a first predetermined period to reduce power consumption of said first physical layer.

31. The energy saving circuit of claim 30 further comprising:

autonegotiation means for communicating with said sense circuit and for powering up said first physical layer and attempting to negotiate a connection with a second physical layer of a second network device when said sensing means generates said receive signal.

32. The energy saving circuit of claim 31 wherein said sensing means enters a sense state and powers down said first physical layer when said sensing means is reset.

33. The energy saving circuit of claim 32 further comprising a first timing means for generating a first signal after a first period.

34. The energy saving circuit of claim 33 wherein said first timing means is reset whenever said receive signal is generated by said sensing means.

35. The energy saving circuit of claim 34 wherein if said first timing means times out before autonegotiation is complete, said sensing means powers down said first physical layer and returns to said sense state.

36. The energy saving circuit of claim 31 further comprising a link means for triggering a link state when autonegotiation is complete and a link with said second physical layer is established.

37. The energy saving circuit of claim 36 wherein said link means generates a link lost signal when said link is lost.

38. The energy saving circuit of claim 32 wherein said sensing means includes second timing means for communicating with a transmitter.

39. The energy saving circuit of claim 38 wherein when said second timing means times out, said transmitter is turned on and generates a pulse.

40. The energy saving circuit of claim 39 wherein after said transmitter generates said pulse, said transmitter is turned off and said sensing means returns to said sense state.

41. The energy saving circuit of claim 40 wherein said second timing means has a second period that is longer than a period of fast link pulse bursts.

42. The energy saving circuit of claim 30 further comprising switching means for sensing a connection configuration of said second physical layer and for adjusting a connection configuration of said first physical layer to match said connection configuration of said second physical layer.

43. The energy saving circuit of claim 30 further comprising status indicator means for generating a status signal to notify said first network device of a power status of said first physical layer.

Patent 4210665

44. A first network device including a first physical layer that establishes and maintains a connection to a second physical layer of a second network device, said first physical layer comprising:

receiving means for detecting connection activity; and

energy saving means for communicating with said receiver and including a first energy saving mode that powers down said first physical layer when said receiving means does not detect said connection activity for a first predetermined period.

45. The first network device of claim 44 further comprising transmitting means for communicating with said energy saving means.

46. The first network device of claim 45 wherein said energy saving means has a second energy saving mode that periodically powers up said transmitting means, generates a link pulse using said transmitting means and then powers down said transmitting means.

47. The first network device of claim 46 wherein said energy saving means includes sensing means for communicating with said receiving means and for generating a receive signal when said connection activity is detected by said receiving means.

48. The first network device of claim 47 wherein said energy saving means includes autonegotiation means for communicating with said sensing means and for attempting to negotiate a connection with said second physical layer when said sensing means generates said receive signal.

49. The first network device of claim 48 wherein said sensing means enters a sense state and powers down said first physical layer when said sensing means is reset.

50. The first network device of claim 49 further comprising first timing means for generating a first signal after a first period.

51. The first network device of claim 50 wherein said first timing means is reset whenever said receive signal is generated by said sensing means.

52. The first network device of claim 51 further comprising link means for communicating with said autonegotiation means and for entering a link state when autonegotiation is successful and a link with said second physical layer is established.

53. The first network device of claim 52 wherein said link means generates a link lost signal when said link is lost.

54. The first network device of claim 50 wherein if said first timing means times out before autonegotiation has completed, said sensing means powers down said first physical layer and returns to said sense state.

55. The first network device of claim 47 wherein said sensing means includes second timing means that communicates with a transmitting means.

56. The first network device of claim 55 wherein when said second timing means times out, said second timing means generates said link pulse.

57. The first network device of claim 56 wherein said second timing means has a second period that is longer than a period of fast link pulse bursts.

58. The first network device of claim 57 wherein after said transmitting means generates said link pulse, said transmitting means is turned off and said sensing means returns to said sense state.

TOP SECRET

59. A method for saving energy in a first physical layer of a first network device, comprising:

generating a receive signal using a sense circuit when connection activity that exceeds a first threshold is detected by a receiver; and

powering down said first physical layer when said receiver does not detect said connection activity for a first predetermined period to reduce power consumption of said first physical layer.

60. The method of claim 59 further comprising powering up said first physical layer and attempting to negotiate a connection with a second physical layer of a second network device using an autonegotiation circuit when said sense circuit generates said receive signal.

61. The method of claim 60 further comprising
entering a sense state of said sense circuit; and
powering down said first physical layer when said sense circuit is reset.

62. The method of claim 61 further comprising generating a first signal that resets said sense circuit after a first period using a first timer.

63. The method of claim 62 further comprising resetting said first timer whenever said receive signal is generated by said sense circuit.

64. The method of claim 63 further comprising:
powering down said first physical layer using said sense circuit if
said first timer times out before autonegotiation is complete;
returning said sense circuit to said sense state.

65. The method of claim 60 further comprising triggering a link state
when autonegotiation is complete and a link with said second physical layer is
established.

66. The method of claim 65 further comprising generating a link lost
signal when said link is lost.

67. The method of claim 61 wherein said sense circuit includes second
timer for communicating with a transmitter.

68. The method of claim 67 further comprising turning on said
transmitter and generating a pulse when said second timer times out.

69. The method of claim 68 further comprising turning off said
transmitter and transitioning said sense circuit to said sense state after said
transmitter generates said pulse.

70. The method of claim 69 wherein said second timer has a second period that is longer than a period of fast link pulse bursts.

71. The method of claim 60 further comprising:
sensing a connection configuration of said second physical layer;
and
adjusting a connection configuration of said first physical layer to match said connection configuration of said second physical layer.

72. The method of claim 59 further comprising generating a status signal to notify said first network device of a power status of said first physical layer.

059043-1101
TOTAL 26706650

73. A method for operating a first network device including a first physical layer that establishes and maintains a connection to a second physical layer of a second network device, comprising:

operating an energy saving circuit in a first energy saving mode;
detecting connection activity; and
powering down said first physical layer when said receiver does not detect said connection activity for a first predetermined period using said energy saving circuit.

74. The method of claim 73 further comprising linking a transmitter with said energy saving circuit.

75. The method of claim 74 further comprising periodically powering up said transmitter, generating a link pulse using said transmitter and then powering down said transmitter using a second energy saving mode of said energy saving circuit.

76. The method of claim 75 further comprising:
providing a sense circuit; and
generating a receive signal using said sense circuit when said connection activity is detected by said receiver.

77. The method of claim 76 further comprising:
providing an autonegotiation circuit; and
communicating with said sense circuit and attempting to negotiate a
connection with said second physical layer when said sense circuit
generates said receive signal.

78. The method of claim 77 further comprising transitioning said sense
circuit to a sense state and powering down said first physical layer when said
sense circuit is reset.

79. The method of claim 78 further comprising generating a first signal
after a first period using a first timer.

80. The method of claim 79 further comprising resetting said first timer
whenever said receive signal is generated by said sense circuit.

81. The method of claim 80 further comprising communicating with said
autonegotiation circuit and entering a link state when autonegotiation is
successful and a link with said second physical layer is established.

82. The method of claim 81 further comprising generating a link lost
signal when said link is lost.

84. The method of claim 76 further comprising providing a second timer that is linked to a transmitter.

85. The method of claim 84 further comprising generating said link pulse using said transmitter when said second timer times out.

86. The method of claim 85 wherein said second timer has a second period that is longer than a period of fast link pulse bursts.

87. The method of claim 86 further comprising turning off said transmitter and returning said sense circuit to said sense state after said transmitter generates said link pulse.

88. A network comprising:

a first network device including a first physical layer with a first energy saving circuit, a first receiver, and a first sense circuit that communicates with said first receiver and that generates a receive signal when connection activity that exceeds a first threshold is detected by said first receiver, wherein said first energy saving circuit powers down said first physical layer when said first receiver does not detect said connection activity for a first predetermined period to reduce power consumption of said first physical layer; and

a second network device including a second physical layer with a second energy saving circuit, a second receiver, and a second sense circuit that communicates with said second receiver and that generates a receive signal when connection activity that exceeds a second threshold is detected by said second receiver, wherein said second energy saving circuit powers down said second physical layer when said second receiver does not detect said connection activity for a second predetermined period to reduce power consumption of said second physical layer.

89. The network of claim 88 further comprising:

a first autonegotiation circuit that communicates with said first sense circuit and that powers up said first physical layer and attempts to negotiate a connection with said second physical layer of said second network device when said first sense circuit generates said receive signal.

90. The network of claim 89 wherein said first sense circuit enters a sense state and powers down said first physical layer when said first sense circuit is reset.

91. The network of claim 90 further comprising a first timer that generates a first signal after a first period.

92. The network of claim 91 wherein said first timer is reset whenever said receive signal is generated by said first sense circuit.

93. The network of claim 92 wherein if said first timer times out before autonegotiation is complete, said first sense circuit powers down said first physical layer and returns to said sense state.

94. The network of claim 89 further comprising a first link circuit that triggers a link state when autonegotiation is complete and a link with said second physical layer is established.

95. The network of claim 94 wherein said first link circuit generates a link lost signal when said link is lost.

96. The network of claim 90 wherein said first sense circuit includes a second timer that communicates with a first transmitter.

97. The network of claim 96 wherein when said second timer times out, said first transmitter is turned on and generates a pulse.

98. The network of claim 97 wherein after said first transmitter generates said pulse, said first transmitter is turned off and said first sense circuit returns to said sense state.

99. The network of claim 98 wherein said second timer has a second period that is longer than a period of fast link pulse bursts.

100. The network of claim 88 further comprising a first switching circuit that senses a connection configuration of said second physical layer and that adjusts a connection configuration of said first physical layer to match said connection configuration of said second physical layer.

101. The network of claim 88 further comprising a first status indicator that generates a status signal to notify said first network device of a power status of said first physical layer.

102. A network comprising:

a first network device including a first physical layer including a first receiver that detects connection activity and a first energy saving circuit that communicates with said first receiver and that has a first energy saving mode that powers down said first physical layer when said receiver does not detect said connection activity for a first predetermined period; and

a second network device including a second physical layer including a second receiver that detects connection activity and a second energy saving circuit that communicates with said second receiver and that has a first energy saving mode that powers down said second physical layer when said receiver does not detect said connection activity for a second predetermined period,

wherein said first and second physical layers of said first and second network devices are capable of establishing and maintaining a network connection.

103. The network of claim 102 wherein said first network device further includes a first transmitter that communicates with said first energy saving circuit and wherein said second network device further comprises a second transmitter that communicates with said second energy saving circuit.

104. The network of claim 103 wherein said first energy saving circuit has a second energy saving mode that periodically powers up said first transmitter, generates a link pulse using said first transmitter and then powers down said first transmitter, and wherein said second energy saving circuit has a second energy saving mode that periodically powers up said second transmitter, generates a link pulse using said second transmitter and then powers down said second transmitter.

105. The network of claim 104 wherein said first energy saving circuit includes a first sense circuit that communicates with said first receiver and that generates a first receive signal when said connection activity is detected by said first receiver, and wherein said second energy saving circuit includes a second sense circuit that communicates with said second receiver and that generates a second receive signal when said connection activity is detected by said second receiver.

106. The network of claim 105 wherein said first energy saving circuit includes a first autonegotiation circuit that communicates with said first sense circuit and that attempts to negotiate a connection with said second physical layer when said first sense circuit generates said first receive signal, and wherein said second energy saving circuit includes a second autonegotiation circuit that communicates with said second sense circuit and that attempts to negotiate a connection with said first physical layer when said second sense circuit generates said second receive signal.

107. The network of claim 106 wherein said first sense circuit enters a sense state and powers down said first physical layer when said sense circuit is reset, and wherein said second sense circuit enters a sense state and powers down said second physical layer when said sense circuit is reset.

108. The network of claim 107 wherein said first network device further comprises a first timer that generates a first signal after a first period.

109. The network of claim 108 wherein said first timer is reset whenever said first receive signal is generated by said first sense circuit.

110. The network of claim 109 wherein said first network device further comprises a link circuit that communicates with said first autonegotiation circuit and that enters a link state when autonegotiation is successful and a link with said second physical layer is established.

111. The network of claim 110 wherein said link circuit generates a link lost signal when said link is lost.

112. The network of claim 111 wherein if said first timer times out before autonegotiation has completed, said first sense circuit powers down said first physical layer and returns to said sense state.

113. The network of claim 112 wherein said first sense circuit includes a second timer that communicates with said first transmitter.

114. The network of claim 113 wherein when said second timer times out, said first transmitter generates said link pulse.

115. The network of claim 114 wherein said second timer has a second period that is longer than a period of fast link pulse bursts.

099043-14301
T027-440660

116. The network of claim 115 wherein after said first transmitter generates said link pulse, said first transmitter is turned off and said first sense circuit returns to said sense state.

0990137-44705660

117. A software method for saving energy in a first physical layer of a first network device, comprising:

generating a receive signal using a sense circuit when connection activity that exceeds a first threshold is detected by a receiver; and

powering down said first physical layer when said receiver does not detect said connection activity for a first predetermined period to reduce power consumption of said first physical layer.

118. The software method of claim 117 further comprising powering up said first physical layer and attempting to negotiate a connection with a second physical layer of a second network device using an autonegotiation circuit when said sense circuit generates said receive signal.

119. The software method of claim 118 further comprising

entering a sense state of said sense circuit; and

powering down said first physical layer when said sense circuit is reset.

120. The software method of claim 119 further comprising generating a first signal that resets said sense circuit after a first period using a first timer.

121. The software method of claim 119 further comprising resetting said first timer whenever said receive signal is generated by said sense circuit.

122. The software method of claim 121 further comprising:
powering down said first physical layer using said sense circuit if
said first timer times out before autonegotiation is complete; and
returning said sense circuit to said sense state.

123. The software method of claim 118 further comprising triggering a
link state when autonegotiation is complete and a link with said second physical
layer is established.

124. The software method of claim 123 further comprising generating a
link lost signal when said link is lost.

125. The software method of claim 119 wherein said sense circuit
includes second timer for communicating with a transmitter.

126. The software method of claim 125 further comprising turning on
said transmitter and generating a pulse when said second timer times out.

127. The software method of claim 126 further comprising turning off
said transmitter and transitioning said sense circuit to said sense state after said
transmitter generates said pulse.

128. The software method of claim 127 wherein said second timer has a

129. The software method of claim 118 further comprising:

sensing a connection configuration of said second physical layer;

and

adjusting a connection configuration of said first physical layer to match said connection configuration of said second physical layer.

130. The software method of claim 117 further comprising generating a status signal to notify said first network device of a power status of said first physical layer.

131. A software method for operating a first network device including a first physical layer that establishes and maintains a connection to a second physical layer of a second network device, comprising:

operating an energy saving circuit in a first energy saving mode;
detecting connection activity; and
powering down said first physical layer when said receiver does not detect said connection activity for a first predetermined period using said energy saving circuit.

132. The software method of claim 131 further comprising linking a transmitter with said energy saving circuit.

133. The software method of claim 132 further comprising periodically powering up said transmitter, generating a link pulse using said transmitter and then powering down said transmitter using a second energy saving mode of said energy saving circuit.

134. The software method of claim 132 further comprising:

providing a sense circuit; and
generating a receive signal using said sense circuit when said connection activity is detected by said receiver.

*

135. The software method of claim 134 further comprising:

providing an autonegotiation circuit; and

communicating with said sense circuit and attempting to negotiate a connection with said second physical layer when said sense circuit generates said receive signal.

136. The software method of claim 135 further comprising transitioning said sense circuit to a sense state and powering down said first physical layer when said sense circuit is reset.

137. The software method of claim 136 further comprising generating a first signal after a first period using a first timer.

138. The software method of claim 137 further comprising resetting said first timer whenever said receive signal is generated by said sense circuit.

139. The software method of claim 138 further comprising communicating with said autonegotiation circuit and entering a link state when autonegotiation is successful and a link with said second physical layer is established.

140. The software method of claim 139 further comprising generating a link lost signal when said link is lost.

141. The software method of claim 137 further comprising powering down said first physical layer and returning said sense circuit to said sense state if said first timer times out before autonegotiation has completed.

142. The software method of claim 134 further comprising providing a second timer that is linked to a transmitter.

143. The software method of claim 142 further comprising generating said link pulse using said transmitter when said second timer times out.

144. The software method of claim 143 wherein said second timer has a second period that is longer than a period of fast link pulse bursts.

145. The software method of claim 144 further comprising turning off said transmitter and returning said sense circuit to said sense state after said transmitter generates said link pulse.

095043 1101
03/27/2006